Improvement of water treatment plant efficiency by changing filter media in Bandar Abbas, Iran

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Abstract:

This study was conducted in water treatment plant of Bandar Abbas, south of Iran. This city has more than 400000 people. The water treatment plant is 40 years old and the most important process unit is mono media sand filter which is not able to provide quality and quantity of water for consumers. The aim of study was to finding a performable model to improve treatment plant efficiency. For starting the study two mono and dual media filters were made in pilot scale. After steady state condition in pilots, total organic carbon, residual chlorine and turbidity in influent and effluent of two pilots were tested. Hydraulic surface overflow rate was evaluated in two pilots too. Results showed that Mean of TOC removal for mono media and dual media were 67.8 ± 8.9 mg/l and 38.7± 15.6 mg/l respectively. Mean of residual chlorine concentration in influent was 0.052 mg/l and in effluent were 0.009 mg/l and 0.034 mg/l respectively for mono and dual media. Mean of turbidity concentration in influent was 2.6 NTU and in effluent for mono media and dual media was 1 NTU. Hydraulic surface overflow rate in mono media and dual media were 6.6 $m^3/m^2/h$ and 11.55 $m^3/m^2/h$ respectively. It was concluded that changing filter bed of Bandar Abbas water treatment plant from mono media to dual media will cause quality and quantity enhancement of treated water and it will be cost effective.

Key-Words: Anthracite, mono media, dual media, filter, Bandar Abbas

1 Introduction

Filtration is one the most important process of water treatment. Several types of filtration systems have been used, such as residential filters, slow and rapid sand filters, and dual media filters. Rapid sand filter is the most common type among the deep media filters [1,4]. Media in rapid sand filters may range in size from 0.35 to 1.0 mm, with a coefficient of uniformity of 1.2 to 1.7. A typical size might be 0.5 mm, with an effective size of 1.3 to 1.7 mm. This range of media size has demonstrated the ability to handle turbidities in the range of 5 to 10 NTU at rates of up to 4.88 m3/m2/h [2]. Filtration rates for rapid filters may be as high as 100 to 300 m3/m2/d, or about 50 times the rate of a slow sand filter [3,4].

Increasing of Population and water consumption in all communities has caused mono media filter not be able to produce sufficient treated water, therefore dual-media filtration was used to solve this problem. Dual-media filters usually have layers; The top layer is consist of clean crushed anthracite coal having an effective size of 0.45 mm to 1.2 mm, and a uniformity coefficient not greater than 1.5 and The bottom layer is consist of sand having an effective size no greater than 0.45 mm and a uniformity coefficient not greater than 1.5. Depth of layers are 0.3-0.6 (m) for anthracite and 0.15-0.4 (m) for sand [3-6].

Anthracite and sand differ in shape, Sand is almost spherical, while granule of anthracite is angular, and thus anthracite bed has more porosity than sand [4-5].

The coarse layer on top removes most of suspended particles. The particles that do pass trough this layer are removed by fine media below. As a result, most of the filter bed is used to remove suspended particles. This allows for longer filter runs and higher filtration rates than mono media filters, which traps most suspended matter near the sand surface [1, 3, 6].

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Anthracite has more adsorption power than sand and there is a reason for removal of some harmful matters from water by anthracite [7-8].
In Shahmansouri et al study titled efficiency of used anthracite layer in Isfahan water treatment plant filters for removing organic matters and heavy metals and comparing it to new anthracite bed, results showed that anthracite has good ability to adsorption of organic matters and heavy metals and efficiency of new anthracite is more than used type [9].
In a study as Comparison of single and dual media filtration in a full-scale drinking water treatment plant which conducted in Greece, results showed that dual media filters have greater filtration cycles (around 3 times higher) and filtration rate more than mono media filters [11].
Bandar Abbas (BA), with more than 400000 people, located in south of Iran, has warm climate. Drinking water of BA is supplied from Esteghlal Dam. One the most problem of BA city is related to quality and quantity of treated water. The water has unpleasant taste and odor caused by algal growth in lake of dam.
Rapid sand filter is the main process unit in BA water treatment plant. There are six twine mono media sand filters, dimensions of each filter is 13m in length and 7m in width.
Population increment is reason of deficiency in treated water, 40 years old water treatment plant of BA is not able to provide the needed treated water.
The aim of study was to finding a performable model to improve the quality and quantity of BA water treatment plant.

2 Material and methods:

In this study, the operation of mono and dual media filter beds was examined in two pilot-scale filters in water treatment plant of Bandar Abbas, Iran. Pilots were made from plaxy glass plates (thickness in 2mm) and coated steel (thickness in 10mm). Dimensions were 330cm in height, 40cm in length and 25cm in width (fig 1). There were 80 nuzzles in a square meter of BA water treatment plant filters, area of each pilot bed was 0.1 m^2, thus eight nuzzles installed in every pilot. The discharge rate from each nuzzle was 0.02 liter per second (l/s), so discharge rate of pilot was 0.16 l/s which was regulated by a control valve.
The pilot influent water was the same as of BA treatment plant filters.

After start of pilots and meeting the steady state condition, water samples were taken, 25 samples from effluent and same number from effluent of each pilot. Analysis will be done for turbidity, residual chlorine, total organic compounds (TOC) concentration and hydraulic surface over flow rate (SOR).

Fig 1: constructed pilot of mono and dual media filter for the study

TOC was tested by TOC meter DRB200, accuracy of 0.001 mg/l.
In TOC analysis, CO2 is confounder, therefore it needs to be removed before analyzing. In order to CO2 removal, by use of 0.5 normal HCl, pH was decreased to 2-3, then by nitrogenation, CO2 omitted from sample.
Due to pre-chlorination in BA water treatment plant; there is a little residual chlorine in filters influent. For comparing of residual chlorine removal ability in two pilots, the concentration of residual chlorine was measured by use of digital kit (HACH), accuracy of 0.01 mg/l.
Turbidity was tested by Nephelometric method and digital turbidimeter (HACH), accuracy of 0.01 NTU. Hydraulic surface overflow rate was determined by using flow measurement and related equations.
Statistical analyses were done bye SPSS software, using mean value of interested parameters and t–test.

3 Results:

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Mean of TOC concentration in both pilots influent was 3.62 ± 1.10 mg/l and mean of TOC in effluent for mono media and dual media were 1.11 ± 0.28 mg/l and 2.16± 0.72 mg/l respectively.

Mean of TOC removal for mono media and dual media were 67.8 ± 8.9 mg/l and 38.7± 15.6 mg/l respectively, fig.2.

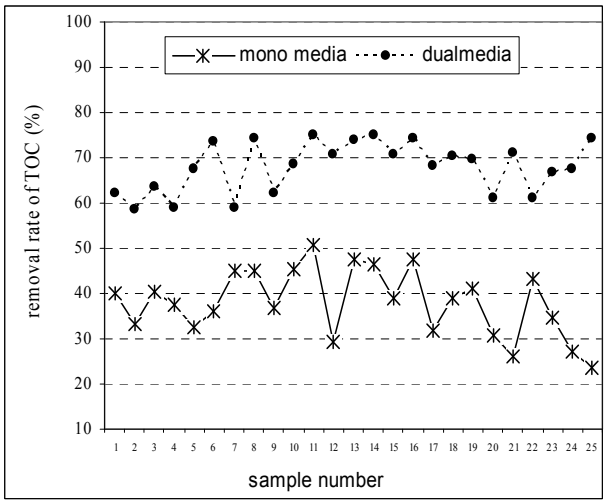

Fig.2: comparison of TOC removal

There was significant difference between two removal means (p-value<0.05).

Mean of residual chlorine concentration in influent of both pilots was 0.052 mg/l and mean of residual chlorine in effluent for mono and dual media filters were 0.009 mg/l and 0.034 mg/l respectively, fig.3.

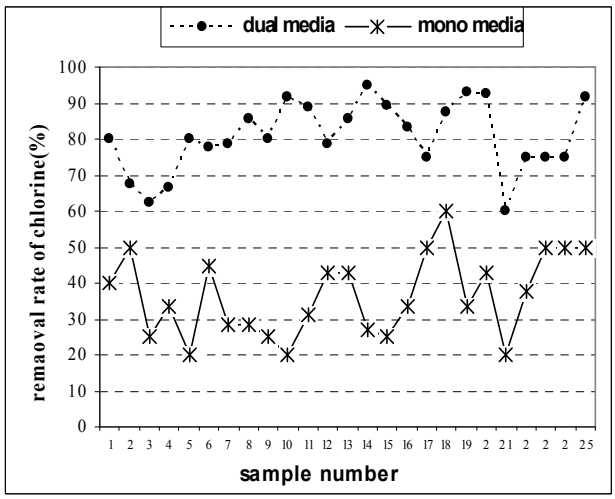

Fig.3: comparison of residual chlorine

There was a significant difference between means of residual chlorine concentration in effluents (p-value<0.05).

Mean of turbidity in influent of both pilots was 2.6 NTU and mean of turbidity in effluent for mono media and dual media pilots was 1 NTU (fig4).

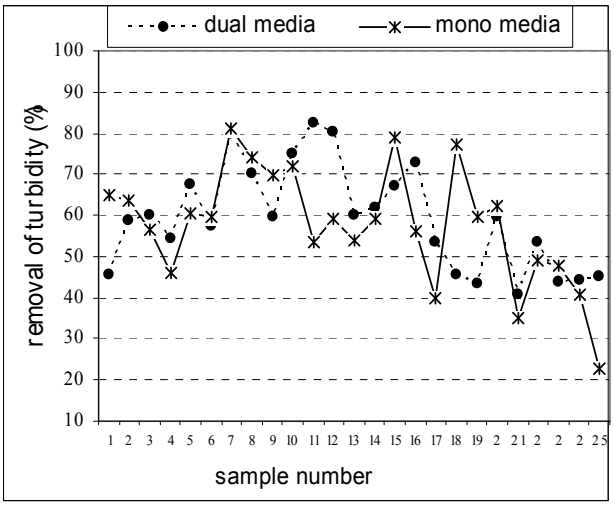

Fig.4: comparison of turbidity removals

There was no significant difference between turbidity means in effluents, (p-value >0.05).

Mean of SOR of mono and dual media filters were 6.5 m3/m2/h and 11.5m3/m2/h respectively, (fig5), there was a significant difference between two means (p-value<0.05).

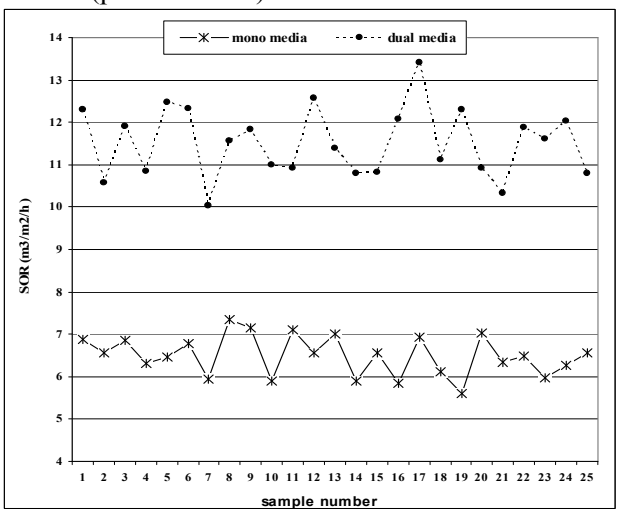

Fig.5: comparison of hydraulic over flow rate

4- Conclusion

Different removal rates of TOC in two pilots' means anthracite media helps organic matters removal. In other words by changing mono media bed to dual media, efficiency of organic matters removal will be enhanced to 67.93 percent.

As mentioned earlier, treated water in BA is involved to taste and odor problems, thus using

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dual media filter instead of mono media can solve this problem in some degree, [Elhadi, S.L.N et al].
Based on results showed in fig (3), better removal of residual chlorine in dual media pilot than mono media is due to adsorption of anthracite layer. It seems that dual media reduce chlorination by-products more than conventional rapid sand filters.
Despite depth of bed in dual media is less than mono media pilot and effective size of anthracite is more than sand media, results showed there is equal efficiency of turbidity removal in two pilots. In justification of this, it can be said that adsorption property of anthracite in dual media and small effective size in sand of mono media have been balanced for turbidity removal.
Based on study results, anthracite bed has nearly good adsorption; therefore it can remove some of precursors of taste and odor causing matters. In order to complete removal of these compounds, it is necessary to use more active martial such as carbon active.
From the standpoint of quantity, 75percent efficiency promotion is achievable. In mono media filters, because of heavy weight of Sand, low filtration rate, and large space requirements; it is not economically to used as single media in water treatment plant filters.
As a conclusion, change of BA filter bed from mono media to dual media will cause quality and quantity enhancement of treated water and it will be cost effective.

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